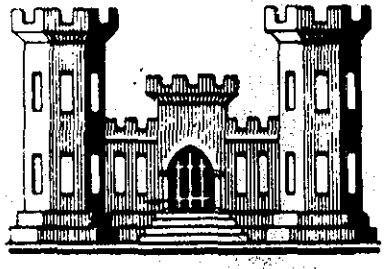
CONNECTICUT RIVER FLOOD CONTROL

HARTFORD
LOCAL PROTECTION

WHITE RIVER
VERMONT

DETAILED PROJECT REPORT

(ADVANCE DRAFT



DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

MARCH 1968

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02154

IN REPLY REFER TO:

NEDED-R

12 April 1968

SUBJECT: *Hartford Local Protection, White River, Connecticut River* Basin, Hartford, Vermont - Advance Draft - Detailed Project Report

Chief of Engineers
ATTN: ENGCW-P

1. In accordance with ER 1165-2-12 dated 1 April 1965, there are submitted herewith, for review and approval, advance draft copies of the Detailed Project Report, Hartford Local Protection, White River, Hartford, Vermont.

2. Appendix A contains a letter of preliminary assurances from the Town of Hartford, which indicates an intention to meet the requirements of local cooperation. Formal assurances of participation will be obtained pending approval and authorization of final designs for the project.

3. Plans and specifications will be prepared substantially in accordance with this report as approved. Funds will be required in the amount of $20,000 for preparation of plans and specifications, and in the amount of $211,000 for construction.

Incl (10 cys)
As stated

REMI O. RENIER
Colonel, Corps of Engineers
Division Engineer

CONNECTICUT RIVER FLOOD CONTROL

HARTFORD

LOCAL PROTECTION PROJECT

WHITE RIVER

HARTFORD, VERMONT

DETAILED PROJECT REPORT

DEPARTMENT OF THE ARMY

NEW ENGLAND DIVISION, CORPS OF ENGINEERS

WALTHAM, MASSACHUSETTS

MARCH 1968

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HARTFORD

LOCAL PROTECTION PROJECT

WHITE RIVER
CONNECTICUT RIVER BASIN
HARTFORD, VERMONT

MARCH 1968

A. PERTINENT DATA

1. Purpose	Ice-jam flood protection
2. Location	White River, Town of Hartford, Windsor County, Vermont
3. Type of Improvement	Channel excavation, removal of rock outcrops and sills, and excavation of an existing earth land projection
4. Hydrology	
Maximum flood stage of record	
With ice:	
Elevation (Hartford Br)	357 ± m. s. l. (March 1964)
Discharge	23,000 c. f. s.
Without ice:	
Elevation (Hartford Br)	362 ± m. s. l. (November 1927)
Discharge	120,000 c. f. s.
Drainage area - White River	712 square miles
5. Principal Quantities	
Rock excavation	13,000 c. y.
Earth excavation	8,000 c. y.
Channel excavation	6,600 c. y.
6. Cost Estimates	
First Costs:	
Federal	$231,000
Non-Federal	9,000
Total	$240,000

6. Cost Estimates (Cont'd)

Annual Costs:

Federal	$ 9,410
Non-Federal	690
Total	$ 10,100

7. Benefits

Average Annual Benefits	$ 13,600
Benefit-cost ratio	1.3 to 1.0

B. PROJECT AUTHORITY

This Detailed Project Report is submitted pursuant to authority contained in Section 205 of the 1948 Flood Control Act, as amended by Public Law 874, 87th Congress, adopted 23 October 1962. Further authority is contained in 1st Indorsement dated 6 January 1967, from the Chief of Engineers to a report, dated 31 October 1966 from Division Engineer, New England Division, Subject: "Reconnaissance Report - Local Protection, White River, Connecticut River Basin, Hartford, Vermont."

C. SCOPE OF DETAILED PROJECT REPORT

1. SCOPE

This Detailed Project Report reviews the ice-jam flood problem and general overbank flooding of the White River in the developed area of Hartford and the village of White River Junction, Vermont. Flooding is caused primarily by runoff and ice-jamming in the reach of the White River from upstream of the Hartford Bridge to its confluence with the Connecticut River. This report submits a definite project plan of channel improvement including excavation of rock outcrops and sills in the river upstream and downstream of the Hartford Bridge and an earth mound projection located downstream of the bridge. The principal portion of the project extends from 2,000 feet upstream of the bridge to about 1,000 feet downstream. Removal of rock and sand and gravel deposits in the lower reach of the White River, downstream to its mouth, is also included in the proposed construction work.

2. TOPOGRAPHIC SURVEYS

A topographic survey of the proposed local protection project area was made during July 1967 on a scale of 1" = 50' and a contour interval of 2 feet. In addition, cross sections of the river were taken in those areas where there were no rock outcrops in order to determine a river bottom profile within the project area.

3. SUBSURFACE EXPLORATIONS

Geological reconnaissance of the proposed project area has been made. Subsurface explorations were performed during September 1967 and consisted of three test pits. These explorations were made in order to determine the extent of earth overburden in a land projection area

located downstream from the Hartford Bridge. Their location and description is shown on Plate No. 2 of this report.

4. ECONOMIC INVESTIGATIONS

A survey of flood damages in the problem area of Hartford was made during July 1964. The survey included personal interviews with town officials, personnel from commercial and industrial firms and residential property owners affected. Also an investigation of economic developments and trends was made to project potential future growth and needs relevant to the project.

5. REAL ESTATE STUDIES

Real estate studies were made during November 1967. Local interests will procure all land rights required. Present indications are that permanent easements for channel improvements will be acceptable. Real estate costs and details of real estate investigations are more fully set forth in Appendix B.

6. CONFERENCES WITH LOCAL OFFICIALS

Close liaison has been maintained with town and state officials and other interested parties. A strong desire for construction and completion of the proposed project has been expressed. A letter of intent indicating the Town's willingness and ability to participate in the proposed improvement and letters from the State and other Federal agencies are contained in Appendix A. Formal assurances will be furnished by the Town of Hartford and the State of Vermont prior to completion of final design.

D. PRIOR REPORTS

7. RECONNAISSANCE REPORT

In response to requests from local interests and in compliance with ER 1165-2-12, a reconnaissance report concerning ice-jam flooding of the White River in Hartford, Vermont was submitted to the Chief of Engineers on 31 October 1966. The report found that channel excavation of rock outcrops and land projections in the vicinity of the Hartford Bridge would relieve the ice-jam flood problem. It also indicated that the project was economically feasible and within the authority of Section 205, Public Law 87-874. It recommended that preparation of a Detailed Project Report be authorized. By 1st Indorsement, dated 6 January 1967, the Chief of Engineers authorized preparation of a Detailed Project Report.

E. DESCRIPTION OF AREA

8. GEOGRAPHY

The Town of Hartford, Vermont is located in Windsor County, along the Connecticut and White Rivers, about 55 miles south of St. Johnsbury, Vermont, and 50 miles northwest of Concord, New Hampshire. The town is comprised of six villages; namely, White River Junction, Hartford, West Hartford, Quechee, Wilder, and Dewey's Mills, and has a permanent population of about 6,400 (1960 census). White River Junction, located at the confluence of the Connecticut and White Rivers and at the intersection of U. S. Highway Routes 4 and 5 is the principal village, rail, and business center of the Town of Hartford. The principal problem area and the site of the proposed local protection project is located along the White River in the vicinity of the Hartford Bridge, and extends downstream to its confluence with the Connecticut River.

9. TOPOGRAPHY

Hartford, Vermont is located in the upland section of New England, a mature region of moderate relief which has been considerably modified by glaciation. Hills are generally rounded and thinly blanketed till. Valleys are relatively wide and are deeply filled with outwash and glacial lake deposits which form broad flood plains in the valley bottoms and extensive terraces along the valley sides. Bedrock in the region consists primarily of phyllitic schist.

10. SURFICIAL GEOLOGY

The project site is located in the upland section of the New England Physiographic Province, locally subdivided and termed the Vermont Piedmont. The region is maturely dissected with minor modification by glacial erosion and moreso by glacial deposition. A temporary lake occupied the White River Valley during glaciation and immense quantities of materials outwashed from the ice were sorted and deposited by tributary meltwaters as stratified sands, silts and clays. The White River since glacial times has eroded the glacial lake deposits to uncover bedrock in the reach of the present day channel through the project. Exposed rock is a phyllitic schist with quartzitic phases having a general trend of foliation north-south or across the river and dip of about 60 degrees easterly or in a downstream direction. Intermittent exposures across the river trend with the strike of foliation and represent the highs of a

ridge and trough surface. The close foliation of the schist will produce slabby and slaty fragmentation.

Subsurface explorations consisting of backhoe excavated pits have been made at three locations in a major shoal area downstream of the Hartford Bridge. These explorations,to an average depth of about 14 feet in overburden,determined that the bedrock surface does not rise appreciably in this area.

11. MAIN RIVER AND TRIBUTARIES

The White River, with a drainage area of 712 square miles, all in Vermont, rises on the northeast slope of Bartell Mountain in the Town of Ripton, and flows east five miles to Granville, then south 19 miles through Hancock and Rochester to Stockbridge where it turns and follows a northeasterly course nine miles to Bethel. It then flows easterly seven miles to South Royalton and finally southeasterly eighteen miles through the Towns of Sharon and Hartford, to its confluence with the Connecticut River at White River Junction, Vermont. The three principal tributaries of the White River are the First, Second, and Third Branches which have drainage areas of 103, 73, and 136 square miles, respectively, and comprise about 44 percent of the total drainage area.

12. STREAM CHARACTERISTICS

The White River has a total length of 58 miles and a total fall of 2,170 feet, of which 1,600 feet occurs in its upper nine-mile reach. In the proposed project area the stream has a slope of about 0.4 percent, falling from elevation 340 m. s. l., located 2,000 feet upstream of the Hartford Bridge, to elevation 327± at a point about 1,000 feet downstream of the Hartford Bridge. From this point, downstream to its confluence with the Connecticut River, the White River has a relatively flat gradient, dropping only 4 feet in the 1.5 mile distance. In the reach upstream of the Hartford Bridge, the river has a width which varies from 300 to 350 feet. Immediately downstream of the bridge, the river is constricted to a width of less than 100 feet by a land projection from the south (right) bank of the river. From this area downstream to the Connecticut River, the width of the White River varies from 150 to 200 feet.

13. MAPS

Topography of the Hartford area is shown on U. S. Geological Survey Maps, indexed as Hanover, Vermont - New Hampshire quadrangle, at a scale of 1:62,500 and a contour interval of 20 feet. The White River Basin is shown on Plate No. 1 of this report.

F. CLIMATOLOGY

14. GENERAL

The White River Basin has a variable climate characterized by frequent but short periods of heavy precipitation. It lies in the belt of the "prevailing westerlies" and consequently in the path of cyclonic disturbances that cross the country from the west or southwest, producing frequent weather changes. The watershed is also affected by occasional coastal storms, some of tropical origin and hurricane intensity which travel up the Atlantic seaboard. The winters are quite severe with subzero temperatures being common. Snow cover usually persists throughout the winter, especially in the areas of higher elevations. Summers are mild with temperatures averaging 60° to 70° Fahrenheit. Precipitation is fairly well distributed throughout the year. Climatological stations in the vicinity of the White River Basin are shown on Plate No. 1.

15. TEMPERATURE

The climate of central Vermont is characterized by long cold winters and relatively mild summers. Freezing temperatures are to be expected from late September to early May. Recorded temperature extremes in the vicinity of the basin have varied from a maximum of 101° Fahrenheit to a minimum of -40° Fahrenheit. Monthly mean, maximum and minimum temperatures at Hanover, New Hampshire, located about 5 miles northeast of Hartford, Vermont, are shown in Table 1.

16. PRECIPITATION

The average annual precipitation at Hanover, New Hampshire is approximately 35 inches. The maximum and minimum annual precipitation at this station are 55.85 and 22.69 inches, respectively. Monthly mean, maximum and minimum precipitation are shown on Table 1.

TABLE 1

MONTHLY TEMPERATURE AND PRECIPITATION
HANOVER, NEW HAMPSHIRE
(Elevation 603 feet msl)

	Temperature (Degrees Fahrenheit) 79 Years of Record			Precipitation (Inches) 123 Years of Record		
Month	Mean	Maximum	Minimum	Mean	Maximum	Minimum
January	18.1	63	-34	2.69	6.76	0.31
February	19.3	63	-40	2.35	7.67	0.32
March	29.6	83	-22	2.64	8.25	0.28
April	42.8	91	6	2.68	6.26	0.07
May	54.9	93	22	3.14	7.37	0.55
June	63.8	98	30	3.34	7.42	0.43
July	68.8	101	38	3.56	9.69	0.51
August	66.2	98	34	3.40	9.83	0.12
September	58.9	95	22	3.18	8.88	0.27
October	47.8	87	13	3.03	9.29	0.12
November	35.2	79	-12	2.79	8.67	0.55
December	22.0	65	-37	2.60	5.05	0.61
ANNUAL	44.0	101	-40	35.40	55.85	22.69

17. SNOWFALL AND SNOW COVER

The annual snowfall for the period of record at Hanover is about 74 inches. The mean monthly and annual snowfall for this area is shown on Table 2. Snow cover, on the average, reaches a maximum depth in late March or early April with water content ranging from 4 to 6 inches. Rapid runoff from melting of the accumulated snow cover occurs every spring, but this cause alone seldom produces damaging floods. However, the possibility of sudden thaws and moderate rains is a potential flood hazard every spring.

18. STORMS

The rapidly moving cyclonic storms that travel across the White River Basin produce frequent periods of unsettled but not severe weather. The region is also exposed to occasional coastal storms, including those of tropical origin, that travel up the Atlantic coast and move inland over New England. The most severe storms are those that develop along a slow moving or stationary front which separates warm, humid air and colder, dry air. In addition, locally violent electrical storms can cause flashfloods on the smaller streams.

G. RUNOFF AND STREAMFLOW DATA

19. DISCHARGE RECORDS

The geographical locations and summary of pertinent data at each of two U. S. Geological Survey gaging stations located within and near the White River Basin are shown on Plate 1 and tabulated in Table 3.

20. RUNOFF

The average annual runoff for the more than 50-year period of record for the White River at West Hartford, Vermont is 1,155 cfs. The maximum, minimum and mean monthly runoff for this station is shown in Table 4.

H. FLOODS OF RECORD

21. NOTABLE FLOODS

a. General. Flood stages and damages are caused by high rates of discharge, ice jams, or a combination of both. The flood of record at Hartford on the White River occurred in November 1927 and was

TABLE 2

MEAN MONTHLY SNOWFALL
HANOVER, NEW HAMPSHIRE
(Elevation 603 feet msl)
78 Years of Record

Average Depth in Inches

Month	Snowfall
January	18.1
February	19.1
March	13.1
April	4.6
May	0.1
June	T
July	T
August	T
September	T
October	0.2
November	5.6
December	13.1
ANNUAL	73.9

TABLE 3

STREAMFLOW RECORDS
THROUGH WATER YEAR 1966

Location	Drainage Area (sq. mi.)	Period of Record	Discharge (cfs) Mean	Maximum	Minimum
White River at West Hartford Vermont	690	1915-1966	1,155	120,000	35*
Connecticut River at White River Junction, Vermont	4,092	1911-1966	7,041	136,000	82**

* Instantaneous Discharge

** Daily Discharge

TABLE 4

MONTHLY RUNOFF
WHITE RIVER AT WEST HARTFORD, VERMONT
(Drainage Area = 690 square miles)
48 Years of Record

Month	Discharge in Cubic Feet Per Second		
	Mean	Maximum	Minimum
January	849	2,418	126
February	718	1,642	173
March	1,877	7,176	221
April	4,057	6,079	1,490
May	1,987	4,733	635
June	911	3,457	223
July	490	1,325	138
August	324	1,221	108
September	386	2,767	80
October	587	2,415	125
November	1,042	4,865	284
December	982	2,657	239
ANNUAL	1,155	1,998	710

caused by rainfall alone. This flood was a major catastrophe in Vermont's history. Records reveal that 22 significant floods, occasioned by runoff and snowmelt, occurred prior to 1927. More recent floods of outstanding importance are those of March 1936 and September 1938.

b. Non-ice Jam Floods. The non-ice floods of November 1927 and September 1938 were caused by heavy rainfall alone. The flood of March 1936 was caused by the combined runoff from rainfall and melting snow. Table 5 shows the notable non-ice flood discharges as recorded at the USGS gaging stations at West Hartford on the White River and White River Junction on the Connecticut River.

TABLE 5

NOTABLE FLOODS
PEAK DISCHARGE IN CFS

	White River at West Hartford	Connecticut River at White River Jct.
Nov. 1927	120,000	136,000
Sept. 1938	47,600	82,400
March 1936	45,400	120,000
June 1947	31,100	63,400
Dec. 1948	31,000	43,000

c. Ice Jam Floods. In recent years, ice jams have occurred with increasing frequency in the White River. They usually form in the vicinity of the Hartford bridge, located about $1\frac{1}{2}$ miles upstream from the confluence with the Connecticut River. When sudden breakup occurs, resulting from either winter or spring thaws, the ice from the fast flowing reaches below the confluence of the First Branch tends to concentrate at bends and obstructions in the river, most notably at the Hartford bridge area. The slowdown in the lower reach due to a decreased slope in the river further increases the concentration of ice at Hartford.

Table 6 lists the ice jams which have been experienced in the Hartford area with the peak discharges occurring on the days that the jams broke up. The noted discharges may, or may not, be concurrent with the highest stage occurring as a result of the ice jam. For example, in the most recent event of March 1964, the ice jam in the White River broke and caused its major damage during discharges increasing from 4,000 to 16,000 cfs. The maximum discharge of 23,000 cfs occurred 12 hours after the jam had moved.

TABLE 6

ICE JAMS
HARTFORD, VERMONT

Date	Discharge (cfs)
February 1867	*
February 1908	*
March 1910	*
March 8, 1946	17,800
March 27, 1953	26,300
January 22, 1959	*
January 31, 1959	*
April 3, 1959	11,300
March 5, 1964	23,000

* Peak discharge unknown

The March 1964 ice-jam flooding followed a series of events starting three months earlier. Freeze-up of the White River began in mid-December 1963 as a prolonged period of subzero temperatures were recorded in the Hartford area. Ice cover extended upstream from the mouth for a distance of about 4 miles. An early thaw during the end of January 1964 with an increase in river flows caused the ice to break up. The flow was not sufficient to flush out the broken ice and it jammed upstream of the Hartford bridge. A return to sub-freezing temperatures in February resulted in a considerable build-up of new ice and solidified the ice jam which remained in place until March.

On the 5th of March 1964, a sharp rise in discharge, as recorded at the West Hartford USGS gage, caused the massive ice jam

to break loose near the upstream railroad bridge around 1 P.M. Its downstream movement was temporarily stalled just upstream of the Hartford bridge until shortly before midnight when another sharp rise in discharge released the jam sending tons of ice down the river. At approximately 1 A.M. on the 6th of March, the huge mass of ice struck and destroyed the U.S. Route 5 highway bridge. It is estimated that a discharge of about 16,000 cfs was occurring when the bridge collapsed. Plate 5 shows a discharge hydrograph for the period of 5-6 March.

The March 1964 ice jams caused an estimated 10-foot rise in water levels upstream of the Hartford bridge. A typical valley cross section upstream of the Hartford bridge is shown on Plate 5 to illustrate the effect of the ice jams on elevating river stages.

I. FLOOD FREQUENCY

22. NON-ICE JAM FLOODS

The frequency, or percent chance of occurrence, of peak non-ice jam discharges on the White River at the West Hartford USGS gaging station was determined by the methods outlined in ER 1110-2-1450, dated 10 October 1962. The frequency data shown in Table 7 and on Plate 5 was developed from values of the log of the mean and standard deviation selected from the regional frequency analysis of the Connecticut River Basin in Vermont.

23. ICE-JAM FLOOD ELEVATIONS

Elevation-frequency relationship for ice-jam flooding has been estimated based on experienced ice-jam floods that have occurred in the Hartford area. Local reports indicate that the two earlier ice-jam floods in 1867 and 1908 in the Hartford area approximated the March 1964 level. With these three comparable events spanning a period of about 100 years, the March 1964 ice jam was assigned a frequency of 3 percent. It is reported that stages, about 10 feet below those of 1964, occur as a result of ice on an average of every two years. The elevation-frequency data shown in Table 8 and Plate 5 is a result of these assigned frequencies.

TABLE 7

DISCHARGE-FREQUENCY DATA
NON-ICE JAM FLOODS
WHITE RIVER

Frequency or % Chance of Occurrence	Unmodified Conditions		Modified by Gaysville Res.	
	Discharge(1)	Water Surface Elevation(2)	Discharge(1)	Water Surface Elevation(2)
	cfs	ft. msl	cfs	ft. msl
0.5	96,000	359.7	57,500	353.6
1.0	75,000	356.5	45,000	351.4
2.0	59,000	354.0	35,400	349.4
5.0	43,000	351.1	25,800	347.0
10.0	34,000	349.0	20,400	345.5
20.0	27,000	347.0	16,200	344.0
30.0	24,000	346.0	14,400	343.2
40.0	21,500	345.1	12,900	342.5
50.0	20,000	344.5	12,000	342.0

(1) USGS Gage at West Hartford, Vermont. Drainage area = 690 Square Miles.

(2) White River at Hartford Bridge.

TABLE 8

ELEVATION-FREQUENCY DATA
ICE JAM FLOODS
WHITE RIVER, HARTFORD BRIDGE

Frequency or % Chance of Occurrence	Ice Jams (ft. msl)
0.5	359.5
1.0	359.5
2.0	358.0
5.0	355.6
10.0	353.5
20.0	351.0
30.0	349.2
40.0	347.6
50.0	346.2

J. PROJECT DESIGN FLOOD

The variables involved with ice-jam flooding preclude establishment of a project design ice-jam flood. The concurrent discharge during the ice-jam flood of March 1964, which produced abnormally high stages in Hartford, was less than 20,000 cfs which is an annual event. The stages for any assumed ice-jam design flood could vary considerably, depending upon the thickness of cover and frazil ice, the duration of the snowmelt period, temperature variations and the amount and timing of precipitation. Because the contemplated project only involves channel clearing and does not include dike or wall construction, a project design ice-jam flood would serve no purpose, and hence has not been determined.

K. EFFECTS OF UPSTREAM RESERVOIRS

The authorized Gaysville Dam and Reservoir will be located on the White River, 31.6 miles upstream of the confluence of the Connecticut River. This project will provide considerable reduction in flood discharges in the White River, but its effect on ice jams, particularly at Hartford, is uncertain and probably not appreciable. Gaysville Reservoir will control the runoff from 226 square miles of watershed, but there are 486 square miles of uncontrolled drainage area in the White River Basin downstream of the reservoir. Local observers report that ice from the First Branch of the White River is the greatest contributor to jams in the West Hartford-White River Junction area with additional contributions from the Second and Third Branches. No other Federal projects are proposed for the White River watershed at this time which would affect ice-jam flooding in the problem area.

L. FLOOD DAMAGE AND ECONOMIC DEVELOPMENT

24. EXTENT AND CHARACTER OF FLOODED AREA

Relatively narrow stretches on both banks of the White River in Hartford, Vermont are subject to ice-jam flooding. On the south side of the river, the flood plain is occupied by an industrial building, a garage and the trackage of the Central Vermont Railroad, while on the north side, residential and commercial properties, and State Highway #14 are subject to inundation and erosion from waterborne ice. Flooding from ice-jams bears little relation to high river flows and as such have been considered as a separate entity.

25. EXPERIENCED AND RECURRING LOSSES

A flood on 5-6 March 1964 caused by an ice jam is considered typical of the type of flood to be expected. Damages in this flood were estimated to exceed $180,000 in the area upstream and just downstream of the Hartford Bridge. A damage survey of the area was made by this office in June of 1964. Based on the survey, it is estimated that a recurrence of this event would cause losses of $181,000 at 1966 price level. In the survey, the stage of zero damage was determined and losses at various stages above and below the 1964 level were estimated and recorded.

26. ANNUAL LOSSES

Recurring losses for various stages of flooding were combined with stage-frequency data to derive annual losses from ice-jam floods. Losses so derived amount to $11,000 at 1966 price level. Derivation of the loss is shown on Plate 5.

27. TRENDS OF DEVELOPMENT

Prior to 1940, the economy of Hartford had been a stable one. Since 1940, the population of the town has grown at a rate which is double the rate of Windsor County and over three times the rate of the State. The Vermont Directory of Manufacturers for 1966/1967 lists 15 small industrial enterprises in Hartford with over two-thirds of the plants concentrated in the White River Junction section which is a little over a mile downstream of the study area. None of the plants are industrial giants, only one employs more than a hundred people, but in the aggregate, industry employs over 30% of the work force and forms a stable base for the economy of the town.

Long known as an important railroad junction on the direct route from Montreal to New York and Boston, the town is now the junction of Interstate Routes I-91 and I-89. Route I-91 is virtually completed from its terminus at I-95 in New Haven, Connecticut to its intersection with I-89 in White River Junction and work is in progress to the north with a completion schedule which calls for reaching the Canadian border at Derby, Vermont, in 1972. Substantial sections of I-89 are completed between White River Junction and Concord, New Hampshire to the east with the balance of the road in that State under construction. To the west of the interchange the section of I-89 between Burlington and Montpelier is complete and construction is under way between Montpelier and White River Junction, with a 1972 completion date scheduled. Part of the interchange complex provides access to the local primary road network.

The impact of these highways will be enormous. Already major trucking concerns are planning freight terminals in the area. Served by both rail and express highway facilities, Hartford's location is ideal as a distribution center for much of central Vermont and western New Hampshire.

Topography and past practices in location of roads and railroad trackage will tend to cause location of terminal facilities in or close to the flood plain. The demand for favorably located land will be such that usage of the flood plain will be at least as high as at the present and will increase with time. It is noted that utilization of the flood plain, after Gaysville Reservoir, is only limited by the ice-jam flood problem. An adjustment was made in annual losses and benefits for the expected increase over the project life of 50 years. Annual losses under current conditions with ice amount to $11,000. Over the next 20 years, the losses are expected to increase by 25% due to increased activity in the area and then grow by 1% annually over the remaining 30 years of project life. The increased activity can be expected on both banks of the river but will be greatest on the south bank. Discounted at $3\frac{1}{4}$%, the average annual equivalent value of the increase amounts to $2600. The total annual loss over the project life amounts to $13,600.

28. FLOOD DAMAGE PREVENTION BENEFITS

Tangible flood damage prevention benefits were derived as the difference between annual losses due to ice-jam floods under current and projected conditions in the Hartford area and annual losses after removal of the ledge. Based on the results of extensive investigations and observations of winter ice conditions made by personnel of CRREL, the removal of rock ledge should considerably reduce the ice-jam problem. Accordingly, the annual benefit equals the entire annual loss of $13,600 due to ice jams.

M. EXISTING AND AUTHORIZED FLOOD CONTROL PROJECTS

There are no existing Corps of Engineers' flood control projects on the White River. A review of engineering, real estate and economic factors affecting a multiple-purpose dam and reservoir project in Gaysville on the White River, about 31.6 miles upstream from the proposed project site at Hartford, Vermont, has been completed. The restudy report was submitted to the Chief of Engineers and the project was reclassified to an "active" category in November 1967.

N. IMPROVEMENTS OF FEDERAL AND NON-FEDERAL AGENCIES

There are no Federal or non-Federal improvements within the White River Watershed which have any affect upon this project.

O. IMPROVEMENTS DESIRED

Several meetings have been held with local interests to determine the attitude of the townspeople and local officials toward the proposed plan of ice-jam flood control. The citizens of the town are desirous of preventing future losses to river bank properties and concur that the proposed plan, as outlined herein, should reduce future damages from ice jams. Local interests have expressed a willingness to fully cooperate on this proposal for flood protection. Letters of comment and concurrence from local interests are included in Appendix A of this report.

P. FLOOD PROBLEM AND SOLUTIONS CONSIDERED

29. FLOOD PROBLEM

The Town of Hartford, Vermont is susceptible to flooding from ice-jams which occur frequently. Damaging ice jam floods have occurred on six occasions since 1946. Flooding from heavy rainfall, melting snow or a combination of both occurs less frequently but is still a threat to the town. The flood of record without ice occurred during November 1927 when an estimated discharge of 120,000 cfs caused the White River to overflow its banks and inundate portions of the villages of West Hartford, Hartford and White River Junction. This flooding was produced entirely by intense rainfall associated with a low pressure system which traveled northward along the Atlantic Coast. About 11 other significant floods caused by runoff alone were experienced from 1885 to 1953.

The maximum ice-jam flood stage occurred in March 1964, when a discharge of 23,000 cfs, coupled with massive ice jams at West Hartford and Hartford, caused overflow of the banks of the White River incurring damages at Hartford and White River Junction. The ice-jam problem at Hartford is primarily caused by existing rock sill obstructions in the river channel and a land projection located just downstream from the Hartford Bridge. The bedrock sills, located upstream of the bridge, retard ice movement so that ice floes jam where the river width is restricted by the land projection. The resulting river stages are raised considerably by the damming effect of the ice until a height is reached when the jam releases and the ice is pushed downstream. In March 1964, this surge of ice moved downstream to White River Junction and jammed again at the Route 5 highway bridge. The force of the ice jam destroyed one section of the bridge before the ice was able to move into the Connecticut River.

30. SOLUTIONS CONSIDERED

Consideration has been given to several alternative solutions to the ice-jam flood problem at Hartford including flood plain zoning, evacuation and resettlement. Evacuation of existing developments within the flood plain was considered unreasonable due to the high value of improved real estate and would cause major dislocation of the local economy. Flood plain zoning would not provide relief to the existing situation. The construction of two concrete ice retention dams to be located 500 feet and 4,000 feet upstream of the Hartford Bridge was also considered. These low dams would provide protection against ice-jam flooding by holding cover ice and frazil ice in a large retention pool during the winter and the ice break-up period in the spring. However, this plan of protection was found to be impractical and uneconomical due to the fact that topographic conditions limit the size of the large pool necessary for ice retention and a large cost would be incurred in relocating about one mile of Vermont Route 14. Also, estimated flood discharges of over 100,000 cfs from the large drainage area would not make the dams effective in retaining cover ice.

Another alternative solution considered was the construction of large multi-purpose reservoirs on major tributaries of the White River. These dams would not be effective in controlling ice because the location of suitable dam sites is far upstream from the site of recurring ice-jams. Similarly, the control of ice by means of low dams on major tributaries was also found to be impractical.

Local protection works, consisting of the construction of a concrete flood wall at the A. G. Dewey Co. building and flood walls and earth dikes along both banks of the White River at White River Junction lacked economic justification owing to the high costs involved. Construction works would be located in the flat flood plains and would be designed to also provide protection from Connecticut River backwater. The plan of improvement would include about 2,000 feet of earth dike and concrete wall construction on the left bank and 1,600 feet of dikes and walls on the right bank. In addition, three vehicular gate structures and interior drainage pumping facilities would be required. The annual costs for such a project would far exceed derived benefits.

Of all the alternates considered, a channel clearing project, primarily in the vicinity of the Hartford Bridge and extending downstream to the mouth of the White River, was found to be the only effective plan having economic justification.

Q. SPECIAL STUDIES

During the period January - March 1966, the U.S. Army Cold Regions Research and Engineering Laboratory (CRREL) located at Hanover, New Hampshire, made extensive investigations and observations of winter ice conditions along a 15-mile reach of the White River extending from its confluence with the Connecticut River upstream to Sharon, Vermont. Observations, depending on meteorological conditions or abrupt changes in ambient temperatures, were made either daily or weekly. A report of their findings was used as a basis for the proposed project plan.

Freeze-up of the White River occurred in early January 1966 and by the 14th of January, the ice thickness averaged seven to nine inches. Areas of open water were present at various locations along the river. During the latter part of January, a heavy snowfall deposited approximately twelve inches of snow on the ice surface. Ice thicknesses had increased three to five inches and open water areas reduced in size. By the 2nd of February, the ice thickness averaged thirteen to nineteen inches.

An early thaw during the period 11-14 February caused numerous and great changes to the ice conditions. Open water areas enlarged and new ones formed. The melting snow raised the water level of the river. Consequently, water was frequently running on top of the ice, and broken ice floes were either rafted onto the main ice sheet or concentrated at bends in the river and at the downstream end of open water areas. These conditions caused numerous but small ice jams to form. Some buildup of slush and frazil ice was found near and in the openings just downstream from the Hartford Bridge. From mid-February to early March, cold weather caused ice in undisturbed areas to freeze to a thickness averaging twenty to twenty-two inches. The buildup of slush and frazil ice noted earlier had dissipated.

During the first part of March, the spring thaw began in earnest. A combination of spring rains and melting snow, followed by warm and sunny weather, extensively reopened the river at the Hartford Bridge area. The swollen river again rafted ice floes on top of the main ice sheet. On the 3rd of March, the main ice sheet was covered with six inches of water, slush and ice. Continued warm weather and rain caused the slush and ice to melt increasing the water level of the river two to three feet which broke up the ice in numerous areas and caused ice jams to form.

On the 4th of March, the air temperature dropped to just below freezing which prevented further melting of the ice. Air temperatures

began to rise again on the 17th of March and final breakup of ice was started. Each day thereafter, more of the ice sheet would break up and the open water areas were enlarging. Some of the ice floes melted but most of them would reach the next downstream ice jam area and stop. By the 20th of March, large ice sheets upstream broke up and moved downstream breaking up small ice jams along the way and formed a larger ice jam just below the Hartford Bridge area. This ice jam was holding back about two feet of water and was held in place by the downstream ice sheet which was the last ice to break up.

Movement of the ice jam occurred on the 21st of March which started the breaking of the large ice sheet downstream. Later during the day the ice sheet shattered and gave way to the ice jam. Water levels increased about one-foot in the downstream reach of the White River. The ice then moved out into the Connecticut River and water levels at the Hartford Bridge area dropped about three feet. There were no losses incurred to persons or property from the ice jam and increases in river stages.

Winter observations made by CRREL indicated that the area most likely to cause ice jam formations is at the Hartford Bridge. The proposed plan of improvements as recommended should prevent any future major ice jams similar to the jam of March 1964.

R. PROPOSED IMPROVEMENT

31. GENERAL DESCRIPTION

The proposed plan for ice jam flood protection at Hartford includes the following improvements which are in agreement with recommendations made by CRREL scientists subsequent to their field studies:

(1) Removal of rock sills in three distinct areas located 300 feet, 1,200 feet and 2,000 feet upstream from the Hartford Bridge. In general, these rock areas extend the full width of the river and require a total of about 10,300 cubic yards of excavation.

(2) Rock excavation of an estimated 2,400 cubic yards of boulders and ledge extending downstream from the Hartford Bridge for a distance of about 1,000 feet. The principal area of this rock is in a large outcrop located 200 feet downstream from the bridge.

(3) Earth excavation of an existing shore projection located 400 feet downstream from the Hartford Bridge currently estimated at 8,000 cubic yards.

(4) Channel excavation of sand and gravel deposits located in the vicinity of the Hartford Bridge. The total estimated volume of this excavation is 3,600 c.y. The major portion of which is located near the right bank at the Dewey Co. building.

(5) Rock excavation of about 300 c.y. of ledge located just upstream from the Interstate 91 highway bridge.

(6) Channel excavation of an estimated 3,000 c.y. of sand and gravel deposition located just downstream from the U.S. Route 4 and 5 highway bridge and further downstream at the confluence of the White and Connecticut Rivers.

Excavated rock and earth material will be spoiled off site, except for that portion of rock which can effectively be utilized as slope protection in those bank areas which might become susceptible to erosion because of the project works. A general layout of the recommended plan for ice-jam flood protection in Hartford is shown on Plates No. 2 and 3.

32. DEGREE OF PROTECTION

The proposed plan of protection should prevent a recurrence of the record ice-jam flood of March 1964 and is the most feasible plan for elimination of the formation of ice jams in the Hartford area. In addition to their other recommendations, CRREL scientists suggested that two low retention dams be constructed. However, subsequent meetings with CRREL personnel revealed that construction of the low dams would not be as effective in the retention of cover ice and frazil ice as was previously estimated due to the limited area available for the retention pool and the high runoff discharges from the large drainage area of the White River.

Operation of the authorized Gaysville Dam and Reservoir, located on the White River approximately 32 miles upstream from the site of the proposed improvements, would lower river stages in the Hartford area during periods of flooding. This dam would control a drainage area of 226 square miles. However, it will not be effective in preventing the formation of ice jams and ice-jam flooding in the Hartford area. Consequently, construction of the outlined improvements will supplement flood protection afforded by the proposed Gaysville Dam and Reservoir.

S. MULTIPLE-PURPOSE FEATURES

The proposed plan for ice-jam flood protection at Hartford, Vermont has no multiple-purpose features and is designed for ice-jam flood protection only.

T. RECREATIONAL DEVELOPMENT

The plan of improvement offers no additional or changes to recreational opportunities in the Hartford area and the White River Basin at the present time.

The report of the U. S. Fish and Wildlife Service, included in Appendix A, concludes that the proposed project, as planned, will have no significant effect upon fish and wildlife resources. However, they suggested during preliminary planning, that a flat-bottomed channel would eliminate fish habitat and might also retard passage of fish through the project area during low flows. They were also concerned that silting of the stream would result from channel excavation operations. Because they are compatible with the proposed ice-jam flood protection project, recommendations of the U. S. Fish and Wildlife Service for alleviating these conditions, have been incorporated in the project plan.

The proposed plan of improvement includes sloping the channel bottom (1% grade) toward the center of the river in the areas of proposed channel excavation. This construction will concentrate stream flows into one area thus permitting fish passage through the excavated areas during low flow periods.

Although some silting of the river will result from rock blasting and excavation operations, efforts will be made during construction to hold siltation to a minimum. Excavated earth materials will be hauled off the site so as not to re-enter the river. Existing shade trees will also be preserved to provide cover for existing fish habitat.

At the present time, the lower reach of the White River has been designated by the New England Interstate Water Pollution Control Commission as a class "C" stream. Water usage is suitable for recreational boating, wildlife habitat and game fishes indigenous to the region. The river reach, within the project area, supports a combination cold water-warm water fishery. Principal fish species include smallmouth bass, walleye trout, and rainbow and brown trout. About 15,000 trout were stocked in the Windsor County portion of the White River during 1965. Current fishing pressure has remained at a relatively low level, however, utilization is expected to greatly increase in future years.

U. REAL ESTATE REQUIREMENTS

The acquisition of lands in fee and easements for the proposed project and the cost of these lands will be the responsibility of local interests. There are no highway or cemetery relocations involved in the project. The

total area to be acquired consists of 17 acres of permanent easement and two temporary construction road easements. Appendix B incorporates the details of real estate requirements and estimated costs.

V. ESTIMATES OF FIRST COSTS AND ANNUAL CHARGES

33. GENERAL

Estimates of Federal and non-Federal first costs and annual charges are given in Table 9 and have been prepared on the basis that local interests would furnish all lands, water rights, and rights-of-way required for project construction and be responsible for operation and maintenance of the project after completion. Unit prices used in estimating costs are based on compiled average data for this type of construction in the general area. The prices are based on 1967 price levels and include minor items of work which are not separately detailed.

34. BASIS OF COST ESTIMATES

Detailed cost estimates have been made upon the basis of an efficient and economical design for the prevention of ice jams in the Hartford area. Estimates of quantities are based on neat outlines of the proposed design requirements. Both financial and economic costs were computed as outlined in Engineering Manual 1120-2-104.

35. CONTINGENCIES, ENGINEERING, SUPERVISION AND ADMINISTRATION

Estimates of construction costs have been increased by 15 percent to cover contingencies. The cost of future engineering and design has been taken as 10.3 percent of the construction cost, and supervision and administration as 8.8 percent of the construction cost.

36. BASIS OF ANNUAL CHARGES

Annual charges are based on a project life of 50 years. Federal and non-Federal annual charges include 3.25 percent for interest and 0.823 percent for amortization. In addition, non-Federal operation and maintenance charges were based on the particular site conditions and previous experience with similar projects.

TABLE 9

ESTIMATES OF FIRST COSTS AND ANNUAL CHARGES
LOCAL PROTECTION, HARTFORD, VERMONT

FIRST COST
(1967 Price Level)

Item	Quantity	Unit	Unit Price	Amount	
Federal Cost					
Site Preparation	1	Job	L. S.	$ 3,000	
Stream Control	1	Job	L. S.	10,000	
Rock Excavation	13,000	C. Y.	10.00	130,000	
Earth Excavation	8,000	C. Y.	1.50	12,000	
Channel Excavation	6,600	C. Y.	2.00	13,200	
Total				$ 168,200	
Contingencies, 15%				25,600	
Total Construction Cost				$ 193,800	
Engineering & Design				20,000	(1)
Supervision & Administration				17,200	
Total Estimated Federal First Cost				$ 231,000	
Non-Federal Cost					
Lands and Damages	1	Job	L. S.	$ 9,000	
TOTAL ESTIMATED PROJECT FIRST COSTS				$ 240,000	

(1) Does not include $30,000 for pre-authorization studies.

ANNUAL CHARGES

Federal		
Interest & Amortization (.04073 x $231,000)		9,410
Non-Federal		
Interest & Amortization (.04073 x $9,000)	365	
Operation & Maintenance	325	
Total Non-Federal Annual Charges		690
TOTAL ANNUAL CHARGES	$	10,100

W. ESTIMATES OF BENEFITS

Average annual flood damage prevention benefits, taken as the difference between average annual losses due to ice jam floods current and projected conditions and those losses remaining after construction, amount to $13,600.

X. COMPARISON OF BENEFITS AND COSTS

Average annual benefits for the Hartford Local Protection Project are estimated at $13,600 and average annual costs are estimated at $10,100. The resulting ratio of benefits to cost is 1.3 to 1.

Y. PROJECT FORMULATION AND ECONOMIC JUSTIFICATION

The Division Engineer finds that property along the banks of the White River in Hartford is susceptible to ice-jam flooding. These lands and structures have suffered extensive damages from ice-jam floods in the past. He concludes that a plan of protection consisting of channel improvement should adequately prevent the formation of ice-jams and prevent ice-jam flooding in this reach of the White River. Project formulation resolved itself into one plan of protection which had not only economic justification but also construction feasibility and compatibility with buildings in the area. Protection from ice-jam flooding can be provided most suitably by the plan as submitted herein for approval. A project providing flood protection from overbank flooding caused entirely by runoff producing high river stages would not be economically justified. The proposed project will have very little effect on this type of flood.

Evacuation of existing developments within the flood plain appears unreasonable since the cost would be far in excess of the cost of flood protection and would cause major dislocation of the local economy. State legislation permits the town to enact flood plain zoning. However, zoning which can control future development, will not provide relief to the existing situation. The Town of Hartford, through the Vermont Water Resources Department, has requested this Division to prepare a flood plain information report of the potential flooding conditions on the White River. This report is currently in progress. Upon construction of the Gaysville Reservoir, the residual damage in the area will be very small for non-ice river floods. With elimination of ice-jam flooding, the area would be generally suitable for further development with some restrictions at the lower elevations. These restrictions in the form of zoning can be formulated upon completion of the Flood Plain Information report.

Various alternative plans were formulated to provide protection against both ice-jam and general overbank flooding. Consideration was given to providing local protection works along both banks of the White River, consisting of earth dikes, concrete walls, vehicular gates, and drainage facilities. This plan of improvement would provide protection against non-ice floods as well as those caused by ice-jams. Project first costs were estimated at $1,500,000 which far exceeded derived benefits. In addition, an analysis of providing separate right bank and left bank protection projects was made but also lacked economic justification. Project first costs amounted to about $700,000 along the right bank and $800,000 along the left bank.

Another considered alternative plan for providing ice-jam flood protection included the construction of two concrete ice retention dams to be located upstream of the Hartford Bridge. These low dams would provide protection against ice-jam flooding by holding cover ice and frazil ice, but would not be effective in preventing overbank flooding from high discharges. However, this plan of protection was found to lack economic justification owing to costs in excess of $1,000,000.

A plan for constructing an upstream flood control or multi-purpose dam and reservoir also was considered and investigated. It was determined that potential dam sites were located far upstream and would not be ineffective in controlling ice jams in the lower reaches of the White River.

Plate No. 5 presents damage-frequency curves for ice-jam flood conditions and natural conditions without ice. These curves indicate the range of losses that will be eliminated by the construction of the proposed ice-jam flood control project and also the reduction in losses for natural conditions without ice when modified by the authorized Gaysville project. Losses for non-ice floods were taken for flood stages as modified by the proposed Gaysville Dam and Reservoir. Because of its distance upstream from the proposed ice-jam flood control project and the fact that it would not control ice floes from several major tributaries, it has been concluded that the Gaysville Dam and Reservoir will have no modifying effect on ice-jam floods.

The recommended channel improvement project should adequately meet the need for eliminating major ice jams in the lower reach of the White River at Hartford, Vermont. In addition, the project offered the only economical plan which would afford the Town of Hartford a reasonable degree of protection. Total project first costs of the recommended plan are estimated at $240,000, of which $231,000 represents the Federal share, and $9,000 the non-Federal share. Amortization over a 50-year period

results in an annual cost of $10,100. The plan of protection will yield average annual benefits of $13,600, resulting in a benefit-cost ratio of 1.3 to 1.0.

Z. SCHEDULES FOR DESIGN AND CONSTRUCTION

37. DESIGN

It is estimated that preparation of contract plans and specifications for the project will cost $20,000 and can be completed in six months subsequent to approval of this report.

38. CONSTRUCTION

Construction of the project can be accomplished under a single contract during a nine-month period.

AA. OPERATION AND MAINTENANCE

Maintenance of this project will be the responsibility of local interests. Periodic inspections will be made by the Corps to assure that adequate maintenance is performed in accordance with regulations prescribed by the Secretary of the Army. It is estimated that maintenance of the project will cost local interests $325 annually. An operation and maintenance manual will be provided to the Town of Hartford upon completion of the project.

BB. LOCAL COOPERATION

In accordance with Section 205 of Public Law 87-874 of the 1948 Flood Control Act, as amended, local interests are required to provide without cost to the United States, all lands, easements, rights-of-way, and utility relocations and alterations necessary for the construction and operation of the project; hold and save the United States free from damages due to the construction works and adjust all claims concerning water rights; and maintain and operate all the works after completion in accordance with existing regulations prescribed by the Secretary of the Army. Local interests would also be required to furnish the added assurance that they would contribute to the United States all necessary funds over and above the Federal cost limitation of $1,000,000 should this become necessary. State and town officials have indicated a willingness to fulfill conditions of local cooperation. A letter from the Town Manager, which constitutes preliminary assurances, is included in Appendix A of this report.

In areas where easement takings are not required for construction of project features, the Town of Hartford will establish ordinances to prevent further encroachment in the natural flood plain of the stream. The channel would be maintained and kept free of obstructions and debris by local interests. In addition, the town would be responsible for imposition of the following restrictions on the floodway: (1) no new construction of any type will be permitted, and (2) existing hazardous structures will be removed when obsolete.

CC. COORDINATION WITH OTHER AGENCIES

Plans for local protective works in Hartford have been reviewed by officials of the Town of Hartford and the State of Vermont. Their endorsement of the proposed plan is indicated by letters in Appendix A. Copies of comments from other Federal agencies are also included as exhibits in Appendix A of this report. The project has no effect on hydroelectric power generation, recreation, pollution abatement, fish migration, or other collateral water resource uses.

DD. CONCLUSIONS

Investigations and studies for the local protection project covered by this report lead to the following conclusions:

a. The Town of Hartford, Vermont, faces an annual threat from ice-jam flooding. A recurrence of the March 1964 ice-jam flood stages would cause losses amounting to $181,000 under present conditions.

b. The desires of local interests are for the best form of ice-jam flood protection that can be afforded to their industrial, commercial and residential properties which would secure the economic base of the Town.

c. Ice-jam flood protection can be provided most suitably and economically by the proposed plan at a total estimated Federal first cost of $231,000 and a local cost of $9,000.

d. The project is economically justified by the ratio of annual benefits to annual costs of 1.3 to 1.0.

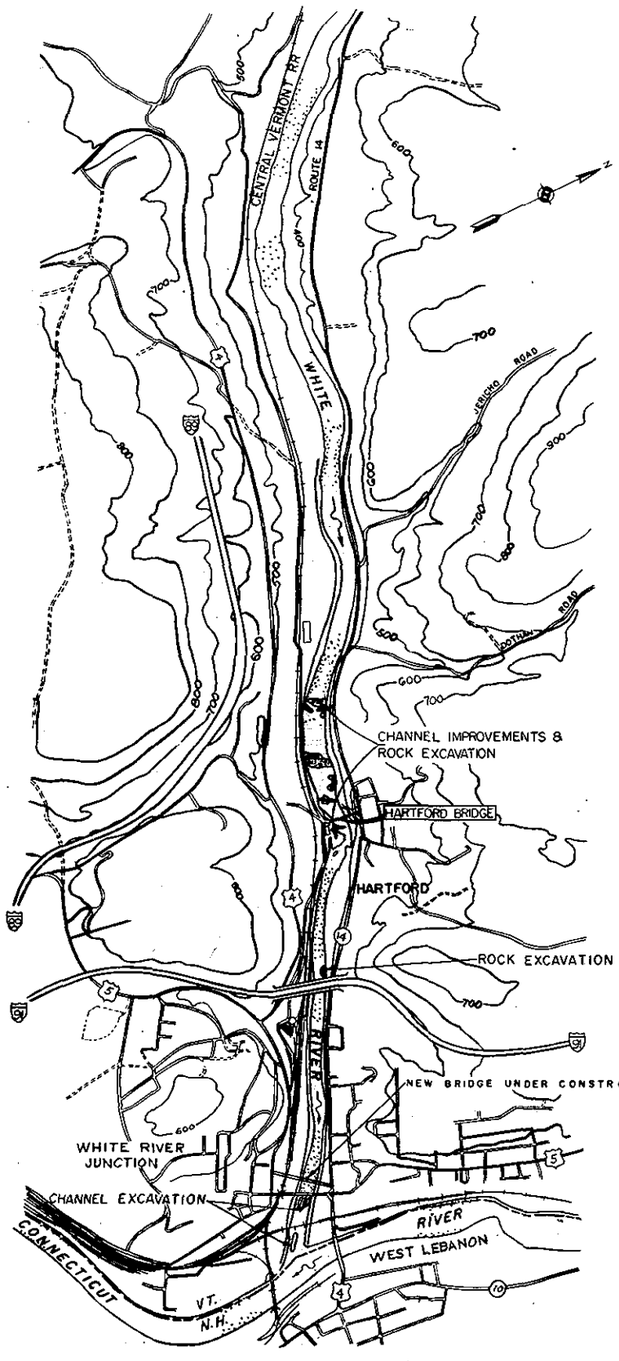
e. The threat of recurring damaging ice-jam floods makes it desirable to construct the project as soon as possible.

EE. RECOMMENDATIONS

It is recommended that the project, as submitted in this report, be authorized by the Chief of Engineers under the provisions of the 1948 Flood Control Act, as amended, and that funds be allotted in the amount of $20,000 for preparation of contract plans and specifications.

CORPS OF ENGINEERS

U. S. ARMY

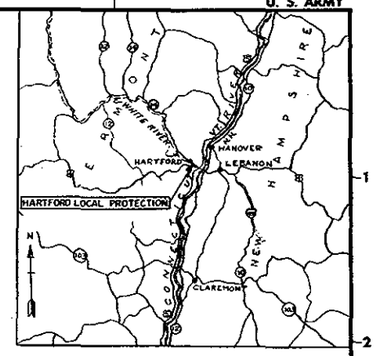


PROJECT PLAN

SCALE: 1"= 1000'

BASIN PLAN

SCALE: 1"=2.5 MILES



LOCATION MAP

SCALE: 1"= 5 MILES

NOTE:
Shaded area indicates approximate limit of March 1964 ice-jam flood.

LEGEND

- ▲ U S G S GAGING STATION
- ◑ RECORDING PRECIPITATION
- ○ NON - RECORDING PRECIPITATION
- ⊸○ NON - RECORDING PRECIPITATION AND TEMPERATURE

GRAPHIC SCALES

1" = 1000'
2" = 5 MI.
1" = 5 MI.

REVISION	DATE	DESCRIPTION	BY

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY C.W.H. | DR. BY A.J.Z. | CK. BY

SUBMITTED: CHIEF, SECTION

REVIEWED: PROJECT ENGINEER

APPROVED: CHIEF, DESIGN BRANCH

APPROVED DATE MARCH 1968
CHIEF, ENGINEERING DIVISION

CONNECTICUT RIVER FLOOD CONTROL
HARTFORD LOCAL PROTECTION
BASIN AND PROJECT PLAN

WHITE RIVER VERMONT

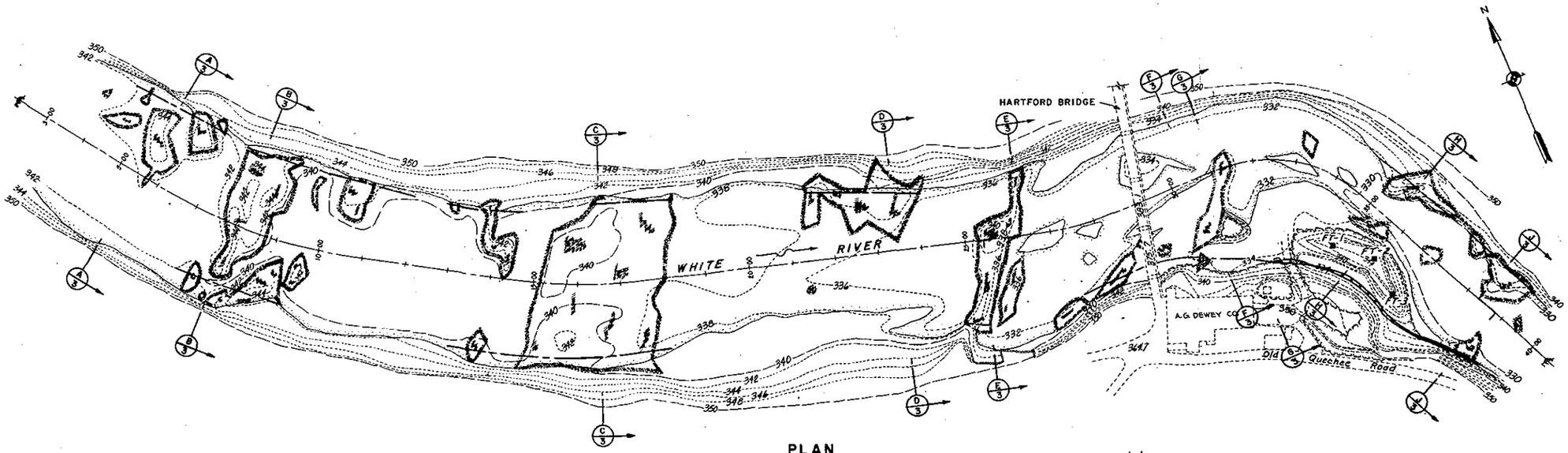
SCALE AS SHOWN | SPEC. NO.

DRAWING NUMBER

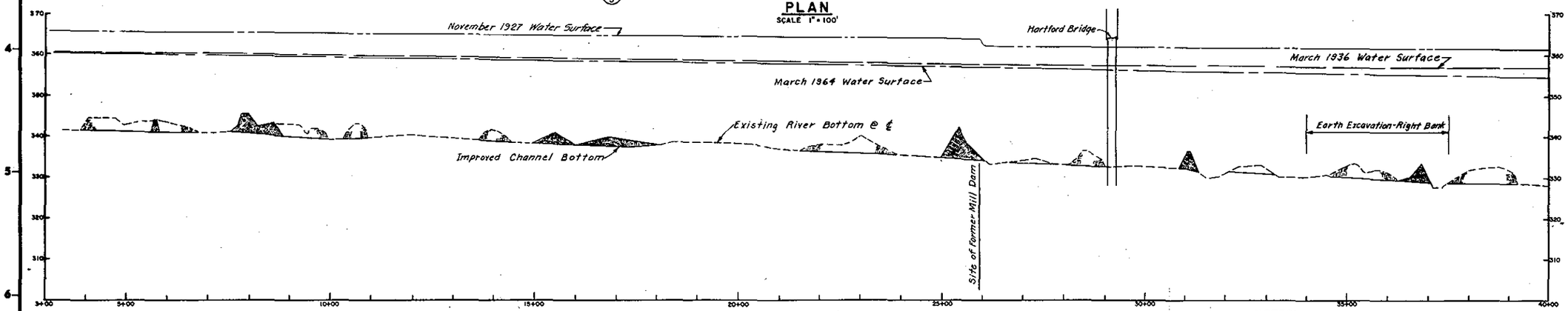
SHEET

PLATE NO. 1

CORPS OF ENGINEERS — U. S. ARMY



PLAN
SCALE 1" = 100'

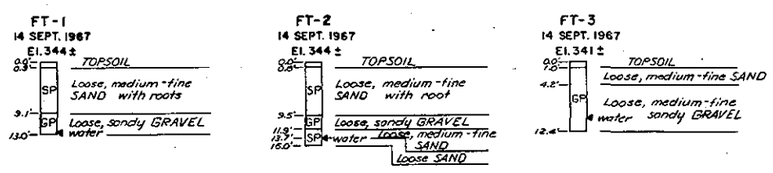


WHITE RIVER PROFILE
SCALE: HOR. 1" = 100'
VERT. 1" = 10'

NOTES:
Elevations refer to Mean Sea Level Datum.
Contour interval equals 2 feet.

SAFETY PAYS

TEST PITS EXCAVATED BY BACKHOE



LEGEND - PLAN
- Edge water surface - July 1967.
- Limits of existing rock outcrops.
- Limits of rock excavation at existing river edge.

LEGEND - PROFILE
- Areas of rock excavation located on ℄.
- Areas of rock excavation along the right and left river banks.
- Areas of channel excavation located on ℄. (Sand and Gravel)

GRAPHIC SCALES
1" = 10': 10' 0 10' 20'
1" = 100': 100' 0 100' 200'

REVISION	DATE	DESCRIPTION	BY

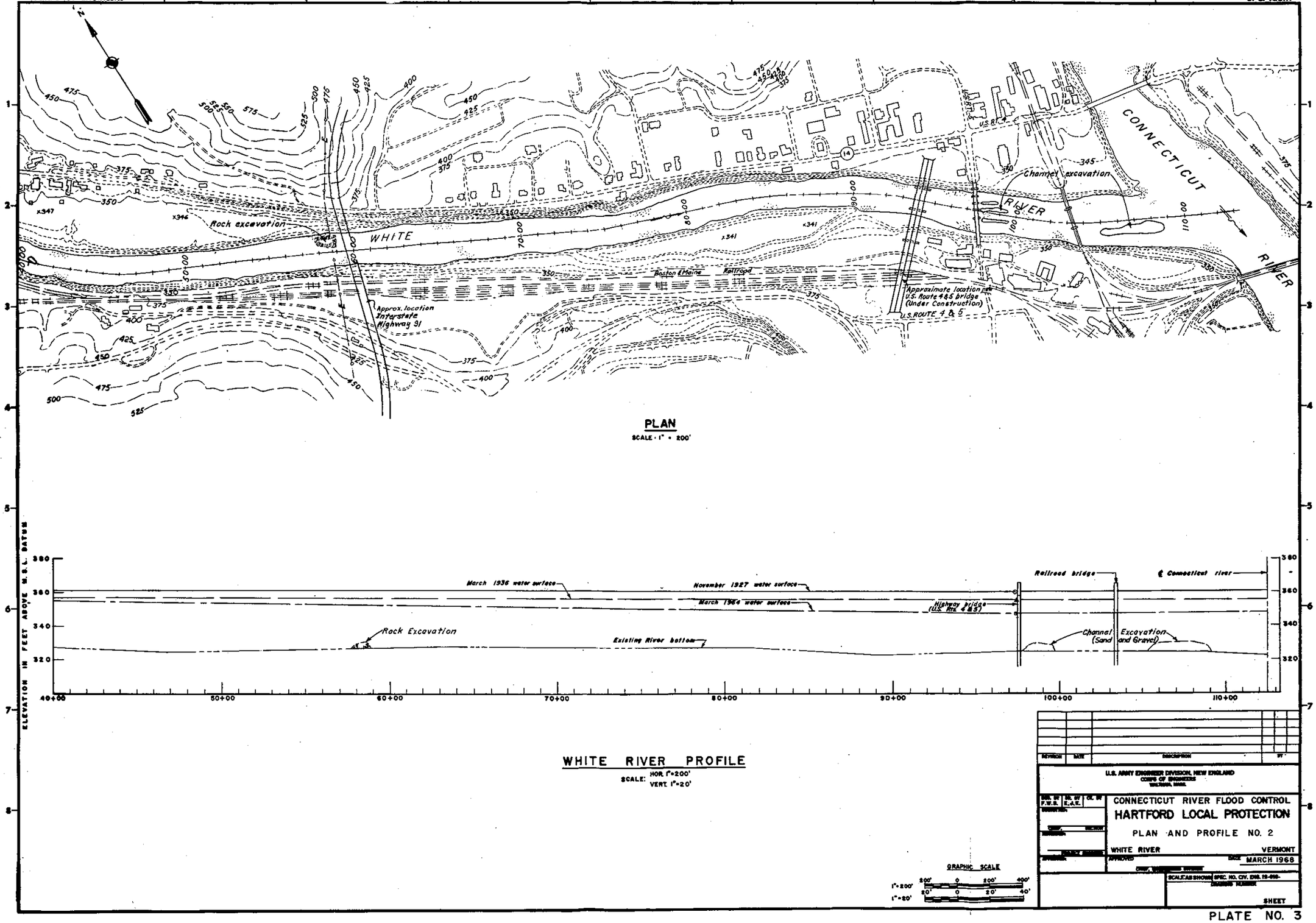
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY F.W.S. | DR. BY R.P.C. | CK. BY
SUBMITTED:
CHIEF, SECTION
APPROVAL RECOMMENDED:
CHIEF, TECH. ENG. BRANCH
REVIEWED:
PROJECT ENGINEER
APPROVAL RECOMMENDED:

CONNECTICUT RIVER FLOOD CONTROL
HARTFORD LOCAL PROTECTION
PLAN AND PROFILE NO. 1
WHITE RIVER — VERMONT
APPROVED — DATE MARCH 1968
CHIEF, ENGINEERING DIVISION
SCALE AS SHOWN | SPEC. NO.
DRAWING NUMBER
SHEET

PLATE NO. 2

CORPS OF ENGINEERS — U. S. ARMY



PLAN

SCALE - 1" = 200'

WHITE RIVER PROFILE

SCALE: HOR. 1"=200'
VERT. 1"=20'

GRAPHIC SCALE

1"=200' 200' 0 200' 400'

1"=20' 20' 0 20' 40'

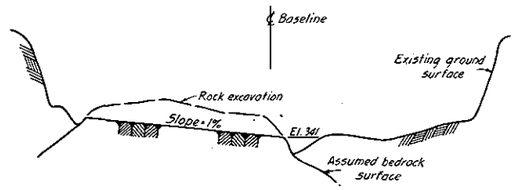
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

CONNECTICUT RIVER FLOOD CONTROL
HARTFORD LOCAL PROTECTION
PLAN AND PROFILE NO. 2
WHITE RIVER — VERMONT
APPROVED — DATE MARCH 1968

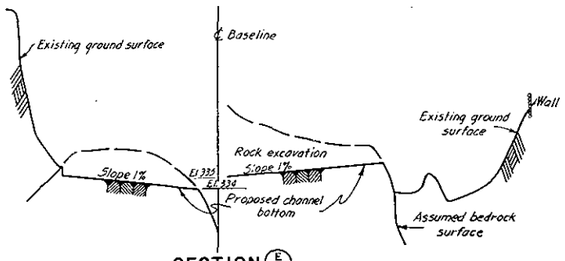
SCALE AS SHOWN — SPEC. NO. CIV. ENG. 19-010-
SHEET

PLATE NO. 3

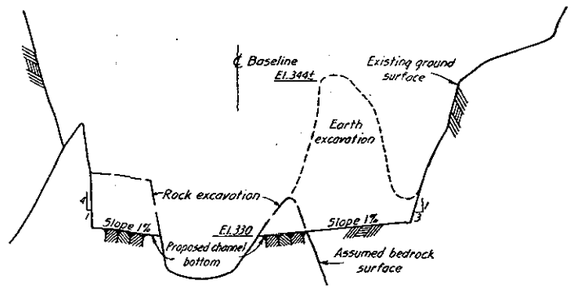
CORPS OF ENGINEERS — U. S. ARMY



SECTION A/2
STA. 5+50



SECTION E/2
STAS. 25+40 & 26+30



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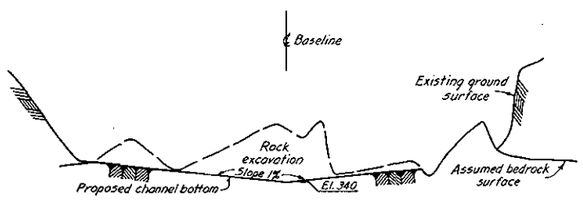
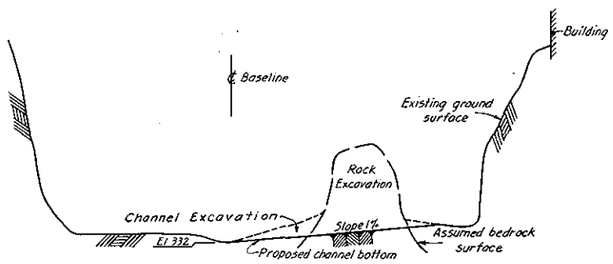
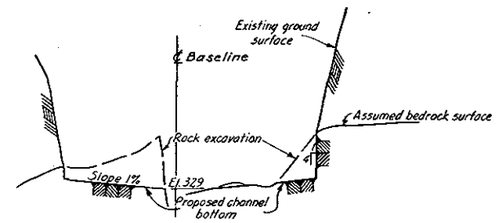


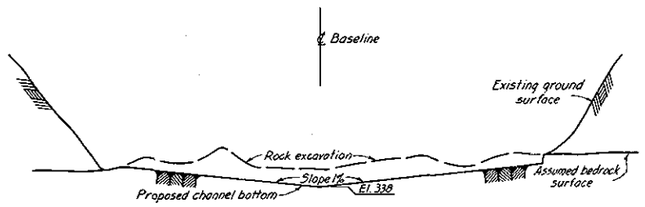
SECTION B/2
STA. 8+00



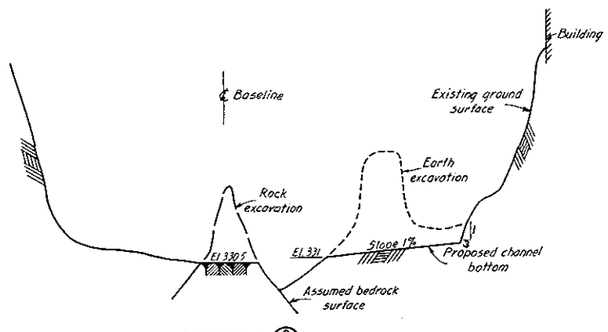
SECTION F/2
STA. 30+50



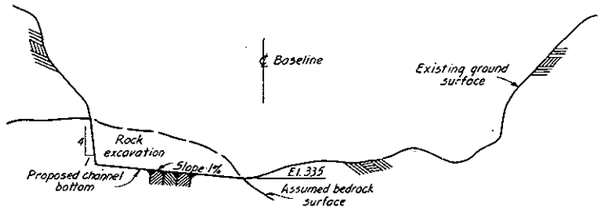
SECTION J/2
STAS. 38+30 & 38+50



SECTION C/2
STA. 16+50



SECTION G/2
STA. 31+10



SECTION D/2
STA. 23+50

NOTES

Excavated rock, suitable for slope protection, will be placed on adjacent river banks which are susceptible to erosion. Excavated earth and excess rock will be hauled off site.

SCALES-ALL SECTIONS
HOR. 1"=50'
VERT. 1"=5'

GRAPHIC SCALES
1" = 5' — 5 0 5 10
1" = 50' — 50 0 50 100

SAFETY PAYS

REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY F.W.S. | DR. BY C.T.M. | CK. BY

SUBMITTED: CHIEF, SECTION

APPROVAL RECOMMENDED: CHIEF, TECH. ENG. BRANCH

REVIEWED: PROJECT ENGINEER

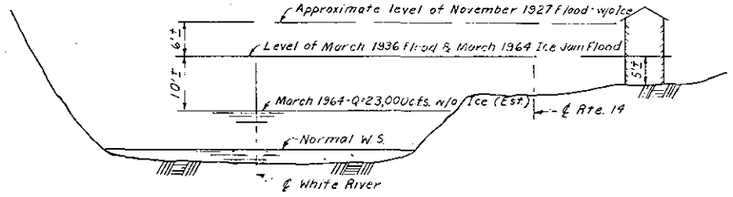
APPROVAL RECOMMENDED: CHIEF, ENGINEERING DIVISION

CONNECTICUT RIVER FLOOD CONTROL
HARTFORD LOCAL PROTECTION
SECTIONS
WHITE RIVER — VERMONT
APPROVED — DATE MARCH 1968

SCALE AS SHOWN | SPEC. NO.
DRAWING NUMBER
SHEET

PLATE NO. 4

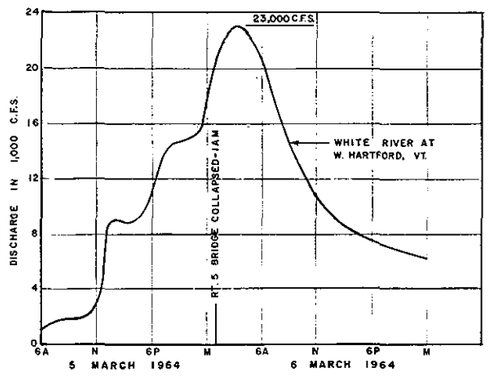
CORPS OF ENGINEERS — U. S. ARMY



TYPICAL VALLEY CROSS SECTION

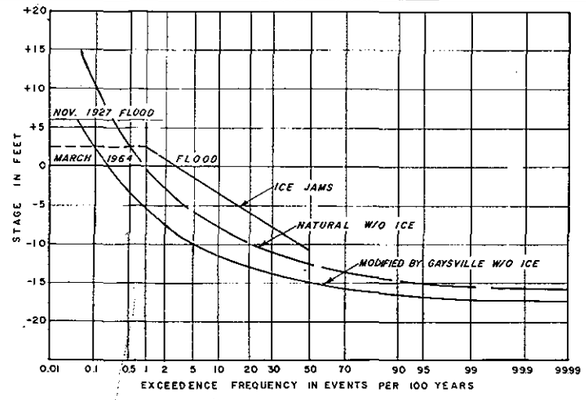
UPSTREAM OF HARTFORD BRIDGE

SCALE: HOR. 1"=50'
VERT. 1"=10'



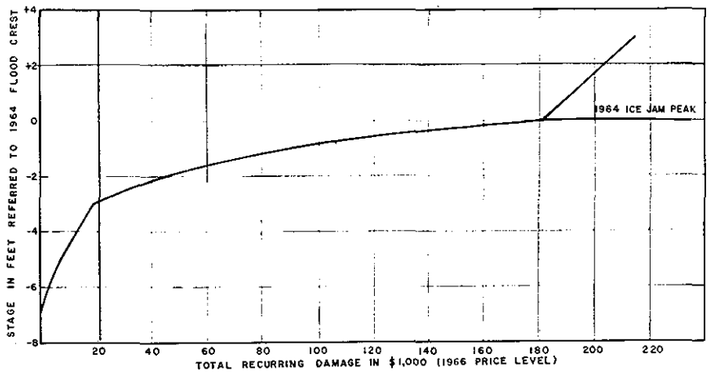
DISCHARGE HYDROGRAPH

WHITE RIVER AT W. HARTFORD VT.

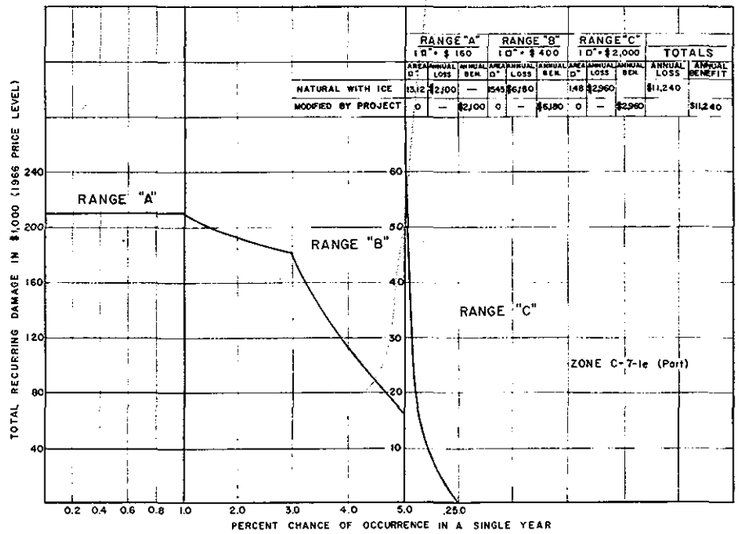


STAGE FREQUENCY CURVE

UPSTREAM OF HARTFORD BRIDGE



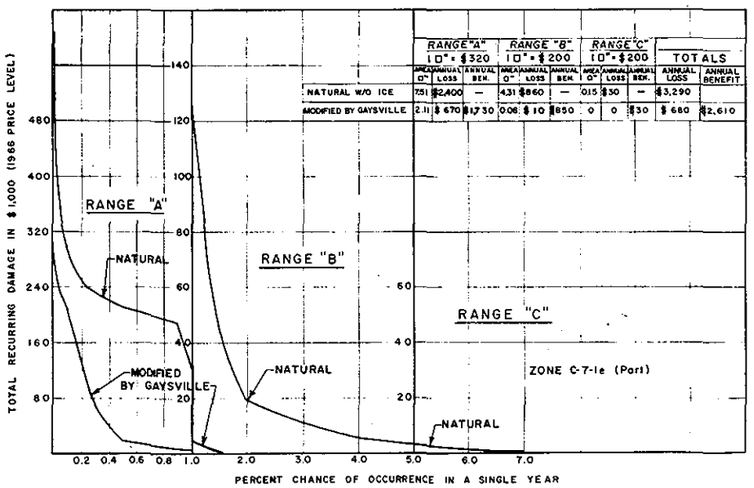
STAGE - DAMAGE



	RANGE "A" $0" = $160			RANGE "B" $0" = $400			RANGE "C" $0" = $2,000			TOTALS	
	AREA $0"	ANNUAL LOSS	ANNUAL BEN.	AREA $0"	ANNUAL LOSS	ANNUAL BEN.	AREA $0"	ANNUAL LOSS	ANNUAL BEN.	ANNUAL LOSS	ANNUAL BENEFIT
NATURAL WITH ICE	13.12	$2,100	—	15.45	$6,180		1.48	$2,960		$11,240	
MODIFIED BY PROJECT	0	—	$2,100	0	—	$6,180	0	—	$2,960		$11,240

DAMAGE - FREQUENCY

ICE JAM CONDITIONS



	RANGE "A" $0" = $320			RANGE "B" $0" = $200			RANGE "C" $0" = $200			TOTALS	
	AREA $0"	ANNUAL LOSS	ANNUAL BEN.	AREA $0"	ANNUAL LOSS	ANNUAL BEN.	AREA $0"	ANNUAL LOSS	ANNUAL BEN.	ANNUAL LOSS	ANNUAL BENEFIT
NATURAL W/O ICE	7.51	$2,400	—	4.31	$860	—	0.15	$30	—	$3,290	
MODIFIED BY GAYSVILLE	2.11	$ 670	$1,730	0.08	$ 10	$850	0	0	$30	$ 680	$2,610

DAMAGE - FREQUENCY

NATURAL CONDITIONS WITHOUT ICE

GRAPHIC SCALES

1"=10' 10' 0 10' 20'

1"=50' 50' 0 50' 100'

SAFETY PAYS

REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY F.W.S. | DR. BY E.J.K. | CK. BY

SUBMITTED: CHIEF, SECTION

APPROVAL RECOMMENDED: CHIEF, TECH. ENG. BRANCH

REVIEWED: PROJECT ENGINEER

APPROVAL RECOMMENDED: CHIEF, ENGINEERING DIVISION

APPROVED: DATE MARCH 1968

CONNECTICUT RIVER FLOOD CONTROL
HARTFORD LOCAL PROTECTION
HYDROLOGIC AND ECONOMIC DATA

WHITE RIVER VERMONT

SCALE AS SHOWN SPEC. NO.

DRAWING NUMBER

SHEET

PLATE NO. 5

APPENDIX A

LETTERS OF CONCURRENCE AND COMMENT

APPENDIX A

LETTERS OF CONCURRENCE AND COMMENT

Exhibit No.	Agency	Letter Dated
1	Town of Hartford, Vermont	28 Dec. 1967
2	State of Vermont Department of Water Resources	21 Nov. 1967
3	U.S. Department of the Interior - Fish and Wildlife Service	28 Dec. 1967
4	U.S. Department of the Interior - Federal Water Pollution Control Administration	21 Feb. 1967
5	U.S. Department of Agriculture - Soils Conservation Service	20 Feb. 1967
6	U. S. Army Cold Regions Research and Engineering Laboratory	2 Nov. 1967

Town of Hartford

General Office
Municipal Building
WHITE RIVER JUNCTION, VERMONT

December 28, 1967

Colonel Remi O. Renier
Division Engineer
U.S. Army Engineer Division, New England
Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02154

Dear Colonel Renier:

We have reviewed the plans as prepared by your office for ice-jam flood protection along the White River in Hartford, and concur in general with this plan of protection.

It is our considered judgment, if and when the project is authorized and funds are allotted for its construction, that the Town of Hartford will meet the prescribed requirements of local cooperation and will agree to:

a) Provide without cost to the United States, all lands, easements, rights-of-way, utility relocations and alterations necessary for project construction;

b) Hold and save the United States free from damages due to the construction works and adjust all claims concerning water rights;

c) Maintain and operate the project after completion without cost to the United States in accordance with regulations prescribed by the Secretary of the Army, currently estimated at $300 per year;

d) Assume full responsibility for all project costs in excess of the Federal cost limitation of $1 million; (The Federal project cost is currently estimated at $162,000); and

e) Prevent future encroachment which might interfere with proper functioning of the project for flood control.

While the power to appropriate funds comes from a vote of the Town, we have every reason to believe that a project of this nature, with its attendant benefits to all concerned, would receive a favorable vote.

You may consider this letter as one of intent by the Town to cooperate locally on this project as is required by the authority of Section 205 of the 1948 Flood Control Act, as amended.

Sincerely yours,

Ralph W. Lehman

RALPH W. LEHMAN
Town Manager

RWL:ds

STATE OF VERMONT
DEPARTMENT OF WATER RESOURCE
MONTPELIER
05602

November 21, 1967

Mr. John Wm. Leslie, Chief
Engineering Division
Department of the Army
New England Division
Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02154

Dear Mr. Leslie:

The local protection project along the White River in Hartford, Vermont, should help in reducing flood and ice damage due to ice jamming conditions.

The removal of channel bedrock and rock sills will no doubt help the passage of ice down the White River and on out into the Connecticut River, thereby safeguarding existing domestic homes and industrial and commercial developments.

The State of Vermont heartily endorses this project and will cooperate with Town and Federal officials in any manner that we can to support the project.

Sincerely,

R. W. Thieme
Commissioner

JEC/RWT/ec

Exhibit 2

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE
U. S. POST OFFICE AND COURTHOUSE
BOSTON, MASSACHUSETTS 02109

December 28, 1967

Division Engineer
New England Division
U. S. Army Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts

Dear Sir:

This letter constitutes our conservation and development report on the local ice-jam flood protection study in the Town of Hartford, Windsor County, Vermont. The study is authorized under Section 205 of Public Law 874, 87th Congress. This report has been prepared under authority of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661-666 inc.) in cooperation with the Vermont Fish and Game Department and has its concurrence as indicated by letter dated December 21, 1967.

We understand that you are considering channel improvements on the White River in the vicinity of the Hartford Bridge about 1.5 miles upstream from the Connecticut River confluence. The plan consists of the removal of channel bedrock outcrops located upstream and downstream of the Hartford Bridge as well as the excavation of an existing land projection located immediately downstream from the A. G. Dewey Company. Channel improvement work will be limited to that area between Station 3+00 and Station 40+00, a distance of 1,850 feet. We are pleased to note that, as a result of the coordination between your staff and ours, certain project modifications have been made for the preservation of the fish and wildlife resources. These modifications include: (1) the channel bottom sections will have a one percent slope in order to concentrate low flows; (2) the excavated rock materials will not be spoiled in those areas where existing vegetation provides shade cover over the river banks; (3) excavated earth materials will be hauled off the site so as not to re-enter the river; and (4) efforts will be made during construction to hold siltation to a minimum.

The project as planned will have no significant effect upon fish and wildlife resources; and, unless the plan of improvement is changed, further study and reporting are not deemed necessary. If project plans are altered, please advise us so we can prepare a new report if necessary.

We appreciate the opportunity to report on your plan.

Sincerely yours,

Richard E. Griffith

Regional Director

River Basin Studies
Reg. Supvr.
Asst. Reg. Supvr.
Corps Projects
Special Studies (C) (A)
MARKS (W) (D)
Admin. Asst.
Clerk- Steno (1) (2)
Files

STATE OF VERMONT
FISH AND GAME DEPARTMENT
MONTPELIER
05602

December 21, 1967

Mr. Thomas A. Schrader
Asst. Regional Director
U.S. Fish & Wildlife Service
Bureau of Sports Fisheries & Wildlife
U.S. Post Office & Courthouse
Boston, Massachusetts 02109

Dear Mr. Schrader:

In answer to your letter of 13 December re the ice-jam flood protection study at Hartford on the White River, I would say that the project, as described, has our concurrence. This office had the opportunity earlier in the year for detailed discussion on this matter with Mr. Fred Benson of the Concord Office of River Basins. At that time the details were worked out with him.

Sincerely,

J.M. MacMartin, Director
Habitat Control Division

JMM/bb

RECEIVED

UNITED STATES
DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
Northeast Region
John F. Kennedy Federal Building
Boston, Massachusetts 02203

February 21, 1967

Mr. John Wm. Leslie
Chief, Engineering Division
U.S. Army Engineer Div., New England
Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02154

Dear Mr. Leslie:

With reference to your letter of 10 February 1967, the preliminary plans showing a possible ice-jam flood protection project in the Town of Hartford, Vermont have been reviewed.

As a result of this review, it is concluded that the project consisting of removal of rock sills in three distinct areas upstream of the Hartford Bridge, and rock and earth excavation downstream from the Bridge for a distance of about 1,000 feet will have no significant effect on the water quality of the river.

The opportunity to review the preliminary plans is appreciated.

Sincerely yours,

Walter M. Newman, Chief
Water Resources Development Activities

Exhibit 4

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

19 Church Street
Burlington, Vermont 05401
February 20, 1967

Mr. John Wm. Leslie, Chief
Engineering Division
Army Corps of Engineers, New England Div.
424 Trapelo Road
Waltham, Massachusetts 02154

Dear Mr. Leslie: Your File NEDED-E

Our staff has reviewed your preliminary plans for the study of the flood plain for Hartford, Vermont. We have no suggestions at this time for improving the study.

Sincerely,

David N. Grimwood
State Conservationist

Exhibit 5

AMXCR-EA(24 Oct 67) 1st Ind
SUBJECT: Ice-Jam Flood Control Project, Hartford, Vermont

U. S. Army Cold Regions Research and Engineering Laboratory, P.O.Box 282, Hanover, New Hampshire 03755 2 November 1967

TO: Division Engineer, U. S. Army Engineer Division, New England, ATTN: NEDED-R, 424 Trapelo Road, Waltham, Massachusetts 02154

1. Upon receipt of the preliminary plans of the proposed channel improvement project on the White River we inspected the river to see whether the two (2) new highway bridges could cause an ice jam. We feel that your proposed plan should eliminate any future major ice jams.

2. If monies are available, we suggest the following added improvements:

a. Eliminate the rock obstructions located upstream from the new Interstate 91 bridge.

b. Remove the sand bar located on White River Junction side of the new bridge over the White River carrying Routes 4 and 5.

c. Remove sand bars and general debris at the mouth of the river where it meets with the Connecticut River.

3. If we can be of further assistance on the proposed project, please contact us.

Kenneth A. Linell
for JOHN E. WAGNER
Lieutenant Colonel, GS
Commanding Officer and Director

wd incl.

NEDED-R 24 October 1967

SUBJECT: Ice-Jam Flood Control Project, Hartford, Vermont

TO: Commanding Officer
U. S. Army Cold Regions Research
and Engineering Laboratory
Hanover, New Hampshire 03755

1. There are inclosed herewith for your review, two sets of preliminary plans showing the limits and scope of the proposed local ice-jam flood protection project on the White River in Hartford, Vermont. Your comments and evaluation of the project are requested.

2. The proposed plan of protection would consist of channel improvements along the White River, in the vicinity of the Hartford Bridge, about 1.5 miles upstream from the Connecticut River confluence. The proposed construction works would include the removal of rock sills and obstacles upstream and downstream of the bridge and the removal of an earth shore projection along the right bank of the river immediately downstream of the A. G. Dewey Company.

3. Our plan of protection is based primarily on recommendations included in your report prepared after ice surveys were made by your engineers during January-March 1966. However, detailed topographic surveys made during low flows of the White River revealed other areas of ledge outcrop which may cause the accumulation of frazil ice. Excavation of these areas has been included as part of the project improvements. The opinion of your engineers and comments regarding the removal of areas of exposed ledge located adjacent to the existing river banks would be helpful.

4. The Detailed Project Report is currently scheduled for submission to the Office of the Chief of Engineers during the latter part of November 1967. An early submission of your comments would be appreciated.

FOR THE DIVISION ENGINEER:

Incl
as

FRANKLIN R. DAY
Lt. Col., Corps of Engineers
Deputy Division Engineer

APPENDIX B

REAL ESTATE

APPENDIX B

REAL ESTATE

APPENDIX B

REAL ESTATE

1. PURPOSE

The purpose of this report is to estimate real estate costs for temporary and permanent easements required for spoil areas and construction of the proposed ice jam flood protection project along the White River in Hartford, Vermont. The estimates of value are contingent upon inspection of the project as of 20 through 22 November 1967 and compilation of data.

2. DESCRIPTION OF AREA

The Town of Hartford, Vermont, is located in the County of Windsor, along the Connecticut River about 55 miles south of St. Johnsbury, Vermont, and 50 miles northwest of Concord, New Hampshire. The town is comprised of six villages; namely, White River Junction, Hartford, West Hartford, Quechee, Wilder and Dewey's Mills, and has a population of about 6,400 (1960 census). White River Junction, located at the confluence of the Connecticut and White Rivers, is the principal village and business center of the Town of Hartford. The principal problem area and the site of the proposed local protection project is located along the White River in the vicinity of the Hartford Bridge, and extends downstream to the Connecticut River confluence at White River Junction.

3. PROJECT AND SITE DESCRIPTION

The proposed plan for ice jam flood protection at Hartford includes improvements which are in agreement with recommendations contained in a report prepared by the Cold Regions Research and Engineering Laboratory located at Hanover, New Hampshire. The project includes excavation of channel bedrock, rock sills and an existing land projection in the vicinity of the Hartford Bridge, and removal of channel shoals immediately downstream of the Route 5 highway bridge in White River Junction and at the confluence of the Connecticut River.

The proposed project affects land of 12 known ownerships, 10 of which are located between the banks of the north side of the river and State Route 14 in the vicinity of the Hartford Bridge. The other two properties are located between the banks of the south side of the river and Old Quechee Road. Approximately 17.0 acres of river bank are to be acquired by permanent easement. Since that portion of excavated rock which is suitable for bank protection will be spoiled along the

river banks, within the proposed permanent easement area, thereby restricting further erosion, no severance damage to these properties are anticipated.

Access to the proposed project area will be from both sides of the river and will allow construction activities for excavation within the river. These access areas are defined as follows:

(1) North Side of River - A dedicated public access road off State Route 14, east of the Hartford Bridge. This access road, referred to as Alber Drive, is routed under the north side of the Hartford Bridge in a westerly direction and extends to private property. Access for construction and maintenance from Alber Drive to the river will involve the acquisition of a permanent access easement over private land involving approximately 3,000 s.f. (20' x 150') of land adjoining the river bank.

(2) Access to the river at the westernmost portion of of the project is via land owned by the State of Vermont adjoining State Route 14. There presently remains an abandoned gravel surfaced road leading to the river which extends approximately 300 feet and involves 6,000 s.f. Temporary easement for access will be required for this land.

(3) South Side of River - Access to the proposed project from the south side of the river is approximately 290 feet east of the Hartford Bridge. It involves an irregular shaped parcel of privately-owned land off Old Quechee Road consisting of approximately 16,000 s.f. of industrial zoned land. A temporary easement for access will be required over this land.

4. UTILITIES

Town water, sewerage, electric and telephone facilities are available.

5. PRESENT AND HIGHEST AND BEST USE

The permanent easement areas are, for the most part, within the present river bed or adjoin the banks thereto. The easement areas on the north side of the river, due to the close proximity to the river bank and irregular plottage are considered as an extension of the river bank. The temporary easement area on the south side of the river is an integral portion of an industrial site.

6. ZONING

Zoning within the perimeter of the project area is diversified. The area on the south side of the river on either side of the

Hartford Bridge is zoned industrial. On the north side of the river the area on the east side of the Hartford Bridge is zoned residential, while west of the bridge for a distance of approximately 400 feet zoning is business. The balance of land is zoned for residential purposes.

7. RELOCATIONS

No relocations are necessary.

8. SPOIL REQUIREMENTS

Excavated rock, that is considered suitable for bank protection, will be placed along the river banks in those areas which are susceptible to erosion. Earth excavation and excess rock will be hauled off-site to the contractor's disposal area.

9. RECOMMENDED ESTATES TO BE ACQUIRED

Partial takings from an estimated 12 properties will be required for the project's construction. It is recommended that real estate interests be acquired under permanent easements. Temporary access road easements are currently scheduled for a one year term.

10. SEVERANCE DAMAGES

Severance damages have been estimated on the basis of "Before and After" appraisal methods. The location of the easements within the river bed and bank precludes severance damages to remainders.

11. ACQUISITION COSTS

Local interests will provide all lands, easements and rights-of-way necessary for construction of the project. Based on experience of this office, costs of acquisition, which include mapping and survey, title work, appraisals, negotiations and closings and administrative costs for condemnation are estimated at $6,000 for the required 12 tracts.

12. ASSUMPTIONS AND LIMITING CONDITIONS

Interests to be acquired will normally be exclusive of the bed and banks of the stream below the ordinary high water line, which is the limit of the existing navigation servitude. (Reference ER 405-2-680, 16 June 1967 Real Estate Local Cooperation Projects). It is assumed that areas required for temporary easements will be restored to reasonable present conditions following construction of the project.

13. EVALUATION

A search was made in the Hartford area to obtain sales data in support of the estimated values assigned. The appraiser was accompanied by the Hartford Town Manager and Town Lister on a tour of the proposed project. Local Realtors and other knowledgeable persons were interviewed to obtain recorded data and value estimates. Knowledge of the real estate market was obtained from this survey and analysis which forms the basis for estimating the real estate costs for the subject project.

Lands affected by permanent easements are considered by the nature of their locations, utility and proximity to the river to have an estimated 50% fee value. Temporary easement values are predicated upon a fair return of invested capital and real estate tax expense for a one year duration, and are estimated at 10% of fair market value per annum and/or nominal fair return for small parcels. The estimated easement values for the subject project are as follows:

Total Estimated Permanent Easement Area - 17.0 Acres:	
17.0 acres @ $100 P/A x 50% =	$ 850.
Land underlying high water line	0.
Permanent Access Road	200.
Temporary Easement for Construction Access - 1 Year	
North Side of River	
Access Right-of-way to River at northwesterly point of Project, from State Route 14 - Nominal	50.
South Side of River	
Access Right-of-way over industrially zoned land, adjoining Old Quechee Road involving approximately 16,000 s. f. and containing 70 feet road frontage - Nominal	100.
TOTAL EASEMENT VALUES	$1,200.

14. COST SUMMARY

Land	$1,200
Severance Damages	0
Acquisition Costs	6,000
Contingencies (20% of $7,200)	1,440
Total Real Estate Costs	$8,640
Rounded to:	$9,000